

containing Fe (III) including Fe(III)OH and equivalents thereof] comprising a source of Fe(III) containing minerals wherein said Fe(III) serves as an electron acceptor for iron-reducing bacteria or other anaerobic bacteria, whereby said Fe(III) containing minerals are one or more selected from the group consisting of Fe(III) hydroxides and oxyhydroxides.

Cancel Claim 52

Claim 53, rewrite as Claim 53 (amended) as follows:

A method for anaerobic bioremediation whereby a solid-chemical composition in accordance with Claim [52 wherein the composition is used as a component in] 51 is applied to contaminated geologic media within a remediation trench, slurry-wall, semi-permeable barrier, [as a well-packing material in a screened well, or other subsurface remedial application] or well-packing material.

#### REMARKS

**With respect to the examiner's remarks (1) and (2)** in the examiner's office action mailed on 3/12/01, Claims 49-53 have been rewritten (as amended above) in a manner believed to clearly define the subject matter as patentable.

**With respect to the examiner's remark (2)** concerning the indefinite nature of the phrase "equivalents to Fe(III)OH" in the original Claim 51, the rewritten Claim 51(as amended) defines a proper Markush group consisting of types of Fe(III)-containing minerals which can serve as microbial electron acceptors for iron-reducing anaerobic bacteria, as described in the inventor's specification. The Markush group consisting of "Fe(III) hydroxides and oxyhydroxides" of the rewritten (as amended) Claim 51 is

understood by those skilled in the art and knowledge of geochemistry and biogeochemistry.

**With respect to the examiner's remarks (3) and (4),** Claims 51 and 53 have been rewritten (as amended above) in a manner believed to clearly define the subject matter as patentable. The inventor has elected to cancel Claim 52.

**Concerning the examiner's remarks (3) and (4),** whereas the inventor readily acknowledges that Fe(III)-containing minerals are common and naturally occurring in earth materials, the use of such minerals as a source of electron acceptors for iron-reducing anaerobic bacteria in a composition for the anaerobic bioremediation of toxic contaminants was not obvious to those skilled in the art at the time the subject patent application was filed with the Patent and Trademark office. Based on the knowledge and experience of the inventor, there is still a widespread lack of understanding of the biogeochemical interactions between microorganisms and Fe(III)-containing minerals, let alone the *specific use of such minerals as sources of anaerobic electron acceptors in solid-chemical compositions for anaerobic bioremediation processes.*

**Regarding the examiner's remark (5),** which expresses the objection that Claims 51 -53 could be anticipated from the prior art cited by the examiner, Claims 51 and 53 have been rewritten (as amended) in a manner believed to patentably define the subject matter. The inventor has elected to cancel Claim 52.

**USP 5,508,194 (Lee)** discloses a nutrient composition containing iron salts, such as ferric chloride ( $\text{FeCl}_3$ ), wherein hydrogen peroxide is used as the oxygen source. The inventor acknowledges that metal compounds, including iron compounds, are used in nutrients, specifically as micronutrients which help catalyze a broad suite of enzymatic processes mediated by microorganisms. Compounds containing ferrous iron, Fe(II), are

more commonly used than the ferric chloride disclosed by Lee, ostensibly due to their generally higher solubilities. While it is not clear from USP 5,508,194, Lee's use of ferric chloride versus one or more ferrous-iron compounds may be based on his use of hydrogen peroxide. Ferrous iron, when combined with hydrogen peroxide, can promote chemical-oxidation reactions that may be harmful to the aerobic bioremediation process disclosed by Lee. Finally, Lee does not disclose the use of ferric-iron compounds or minerals as a source of *electron acceptors* for iron-reducing bacteria in a *solid-chemical composition* for *anaerobic* bioremediation. Therefore, the inventor's subject matter is neither disclosed by nor obvious from Lee et al.

**USP 5,620,893 to Hogen et al.** discloses a method for treating soil and water whereby elemental iron and compounds of ferrous iron and ferric iron are used to remove sulfide contamination associated with sulfate-reduction processes in the environment. Unlike the subject matter, the treatment method disclosed by Hogen et al. involves the integration of both anaerobic and aerobic process steps. The use of  $\text{Fe}_2\text{O}_3$  (idealized magnetite) as the preferred form of ferric iron and siderite ( $\text{FeCO}_3$ ) as the preferred form of ferrous iron is also disclosed by Hunter et al. Hogen et al. do not disclose the use of *ferric hydroxides* and *oxyhydroxides* as a source of *electron acceptors* for iron-reducing bacteria in a solid-chemical composition for anaerobic bioremediation or a method for anaerobic bioremediation involving the use of said solid-chemical composition as does the subject matter of the present invention. Hence, the inventor's subject matter is neither disclosed by nor obvious from Hogen et al.

**USP 5,811,255 to Hunter et al.** discloses an apparatus and method for anaerobic and aerobic respirometry. A table is provided in Hunter et al. (Col. 23) which lists "Ferric Iron ( $\text{Fe}^{+3}$ )" as an electron acceptor for "iron reducers." Hunter et al. disclose in detail the basis and application of their invention as a means of quantifying aerobic and anaerobic microbial processes via a novel apparatus and method for respirometry. Moreover, in

Claim 8 (Col. 49), Hunter et al. specifically disclose a Markush group of "dissolved electron acceptor[s]" other than oxygen that does not include  $\text{Fe}^{+3}$  or compounds containing ferric iron. Hunter et al. do not disclose a method for *anaerobic bioremediation* or a *solid-chemical composition* for anaerobic bioremediation which contains ferric-iron minerals as a source of *electron acceptors* for iron-reducing anaerobic microorganisms, as does the subject matter of the present invention. Accordingly, the inventor's subject matter is neither disclosed by nor obvious from Hunter et al.

In light of the information provided above, it is evident that a person of ordinary skill in the art would not derive the Fe(III)-containing solid-chemical composition for anaerobic bioremediation of the present invention, wherein the Fe(III) serves as a source of electron acceptors for anaerobic microorganisms, via an "obvious" extrapolation from a simple list of Fe(III)-containing minerals or ferric iron compounds, e.g., the Merck Index, the Handbook of Chemistry and Physics, or the like.

**With respect to the examiner's remarks (6) and (7),** Claims 48-50 have been rewritten (as amended) in a manner believed to patentably define the subject matter.

**With respect to the examiner's statement in remarks (6) and (7) that the original Claims 48-50 are unpatentable over the prior art cited,** the inventor respectfully disagrees as enumerated below:

**In regard to USP 4,299,613 to Cardarelli,** it should be noted that Cardarelli does not disclose a nutrient composition containing Mn(IV); the reference to use of manganese chloride by Cardarelli provides manganese in the *reduced* form of  $\text{Mn}^{+2}$ . Moreover, Cardarelli specifically discloses the use of "controlled-release manganese emitters" as a slow-release source of trace-nutrient manganese in composition for promoting the growth of plants. Cardarelli discloses the use of reduced manganese ( $\text{Mn}^{+2}$ ) in the forms of both

manganese chloride and manganese sulfate. Cardarelli also discloses the use of  $Mn^{+4}$  in the form of manganese dioxide in embodiment "10-A" (col. 18, Table X). Cardarelli specifically discloses the use of such materials as "trace nutrients" for plants within a controlled-release matrix of organic-polymers. Cardarelli's table (col. 18, Table X) and text descriptions are a little confusing, as the text refers to "manganese" whereas the footnotes to Table X (col. 18) refer to the magnesium (Mg) compounds  $MgCl_2$  and  $MgSO_4$ . Cardarelli does not disclose the use of Mn(IV) containing minerals as a source of *electron acceptors* for manganese-reducing and other anaerobic microorganisms in a solid-chemical composition for the *anaerobic bioremediation of toxic contaminants*, as in the present invention. Moreover, a non-obvious advantage of the present invention versus Cardarelli is that the present invention avoids the mixture of large proportions of Mn(IV) materials with large proportions of organic polymers. Mn(VI) materials, such as pyrolusite or manganese dioxide, are strong oxidizers which in combination with organic polymers, can create a potentially dangerous mixture. In conclusion, the inventor's subject matter is neither disclosed by nor obvious from Cardarelli.

**USP 5,582,627 to Yamashita** discloses a liquid composition in the form of a "nutrient medium" containing organic substrates such as molasses, macronutrient forms of nitrogen and phosphorus, micronutrient forms of trace metals and other amendments. Yamashita does not disclose the use of *electron-acceptors*, let alone the use of either Fe(III) or Mn(IV) compounds as anaerobic electron acceptors as in the present invention. Yamashita discloses "mixing instructions" (col. 4) for the preparation of his disclosed liquid composition which contains molasses, water and other ingredients in the following order: citric acid; Katy-J complexing agent; phosphoric acid; nitrogen; potassium; micronutrients (separately); vitamins and cofactors; seaweed extract and xanthum gum. Yamashita specifically discloses the use of soluble manganese compounds as the "micronutrient" source of "Mn", including manganese nitrate and other compounds generally containing the reduced  $Mn^{+2}$  form of manganese (col. 6). Yamashita does not disclose the use of

Mn(IV) containing minerals as a source of *electron acceptors* for manganese-reducing and other anaerobic microorganisms in a *solid-chemical composition* for the anaerobic bioremediation of toxic contaminants as in the subject matter of the present invention. Therefore, the present matter is neither disclosed by nor obvious from Yamashita.

**USP 5,804,435 to Kurane et al.** discloses a novel method for obtaining unique strains of the organic-solvent resistant bacterium *Pseudomonas putida*. In a manner similar to that disclosed by Yamashita, Kurane discloses the use of a "culture medium" for bacteria containing manganese chloride, whereas the  $Mn^{+2}$  form of manganese presumably serves as a trace nutrient or "micronutrient" for the above-referenced method. Kurane et al. do not disclose solid-chemical compositions or methods for anaerobic bioremediation. Moreover, Kurane et al. do not disclose the use of Mn(IV) containing minerals as a source of *electron acceptors* for manganese-reducing and other anaerobic microorganisms in a *solid-chemical composition* for the *anaerobic bioremediation* of toxic contaminants as in the subject matter of the present invention. Hence, the inventor's subject matter is neither disclosed by nor obvious from Kurane et al.

Finally, in light of the information provided above, it is evident that a person of ordinary skill in the art would not derive the Mn(IV)-containing solid-chemical composition for anaerobic bioremediation of the present invention, wherein the Mn(IV) serves as a source of electron acceptors for anaerobic microorganisms, via an "obvious" extrapolation from a simple list of manganese-containing compounds, e.g., the Merck Index, the Handbook of Chemistry and Physics, or the like.

### CONCLUSION

For all of the above reasons, applicant submits that the claims are now in proper form, and that the rewritten claims (as amended) define patentably over the prior art. Therefore, applicant submits that this application is now in condition for allowance, which action he respectfully solicits.

**Conditional Request for Constructive Assistance**

Applicant has amended the claims of this application so that they are proper, definite, and define novel structure which is also unobvious. If, for any reason, this application is not believed to be in full condition for allowance, applicant respectfully requests the constructive assistance and suggestions of the Examiner pursuant to M.P.E.P. §2173.02 and §707.07(j) in order that the undersigned can place this application in allowable condition as soon as possible and without the need for further proceedings.

Respectfully submitted,  
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**Attachment - Revised Claims**

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48. A solid-chemical composition for anaerobic biodegradation, detoxification, and transformation of toxic organic and inorganic compounds in contaminated geologic media, comprising a granular source of Manganese (IV) wherein said Manganese (IV) serves as an electron acceptor for manganese-reducing bacteria or other anaerobic bacteria.
49. A solid-chemical composition in accordance with Claim 48, whereby said granular source of Manganese (IV) is one or more selected from the group consisting of glauconite, manganese greensand and pyrolusite.
50. A method for anaerobic bioremediation whereby a solid-chemical composition in accordance with Claim 48 is applied to contaminated geologic media within a remediation trench, slurry-wall, semi-permeable barrier, or well-packing material.
- c1 51. A solid-chemical composition for anaerobic biodegradation, detoxification, and transformation of toxic organic and inorganic compounds in contaminated geologic media, comprising a source of Fe(III) containing minerals wherein said Fe(III) serves as an electron acceptor for iron-reducing bacteria or other anaerobic bacteria, whereby said Fe(III) containing minerals are one or more selected from the group consisting of Fe(III) hydroxides and oxyhydroxides.
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- c2 53. A method for anaerobic bioremediation whereby a solid-chemical composition in accordance with Claim 51 is applied to contaminated geologic media within a remediation trench, slurry-wall, semi-permeable barrier, or well-packing material.
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